

Amendments to the Abstract:

The service lifetime of an ion source (400) is enhanced or prolonged by the source having provisions for ~~ire-site~~ *in-situ* etch cleaning of the ion source (400) and of an extraction electrode (405), using reactive halogen gases (~~F1, F2~~) (F or Cl), and by having features that extend the service duration between cleanings. The latter include accurate vapor flow control, accurate focusing of the ion beam optics, and thermal control of the extraction electrode that prevents formation of deposits or prevents electrode destruction. An apparatus comprised of an ion source for generating dopant ions for semiconductor wafer processing is coupled to a remote plasma source which delivers F or Cl ions to the first ion source for the purpose of cleaning deposits in the first ion source and the extraction electrode. These methods and apparatus enable long equipment uptime when running condensable feed gases such as sublimated vapor sources, and are particularly applicable for use with so-called cold ion sources. Methods and apparatus are described which enable long equipment uptime when decaborane and octadecarborane are used as feed materials, as well as when vaporized elemental arsenic and phosphorus are used, and which serve to enhance beam stability during ion implantation.